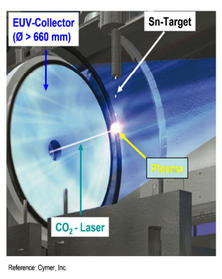
5 sr collector mirror coatings for high power laser produced plasma EUV sources

Marco Perske* **, Hagen Pauer, Torsten Feigl, Norbert Kaiser**
Fraunhofer-Institut für Angewandte Optik und Feinmechanik, Albert-Einstein-Str. 7, 07745 Jena, Germany

1. Introduction

Bringing EUV Lithography (EUVL) forward to high volume manufacturing (HVM), one of the main challenges to date is to deliver a high level of EUV power at intermediate focus (IF). One of the most promising methods to meet the joint requirements from all leading scanner manufacturers is a laser produced plasma (LPP) source. The required 13.5 nm radiation is generated by highly ionized plasma which is created by depositing laser energy at 10.6 µm wavelength into tin (Sn). The radiation of this plasma is collected by a 5 sr near normal incidence EUV collector (Ø 660 mm) and focused to the IF (Figure 1).



In order to achieve the required peak reflectivity of more than 65 %, the ellipsoidal collector was coated with a highly reflective, laterally graded multilayer using dc magnetron sputtering. Coating results of the world's largest EUV collector are presented.

Fig. 1: Schematic illustration of Laser Produced Plasma (LPP) source.

2. Coating Challenges

Collector Dimensions:

Diameter:	**> 660 mm**
Lens sag:	**> 150 mm**
Substrate tilt:	**> 45 deg**
Weight:	**> 40 kg**

Requirements for HVM:

Reflectivity :	**> 65 %**
Wavelength:	**λ = (13.50 ± 0.05) nm**
Accuracy of lateral thickness gradient:	**Δd < 25 pm**

Fig. 2: 5 sr LPP collector.

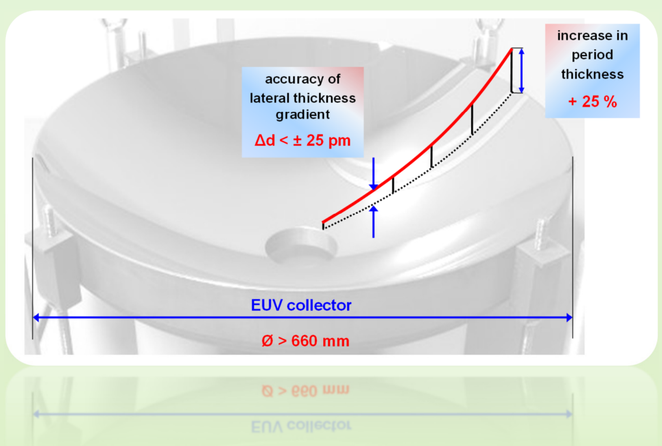


Fig. 3: Collector dimensions and schematic period thickness gradient along collector radius.

3. Technical Coating Setup: NESSY

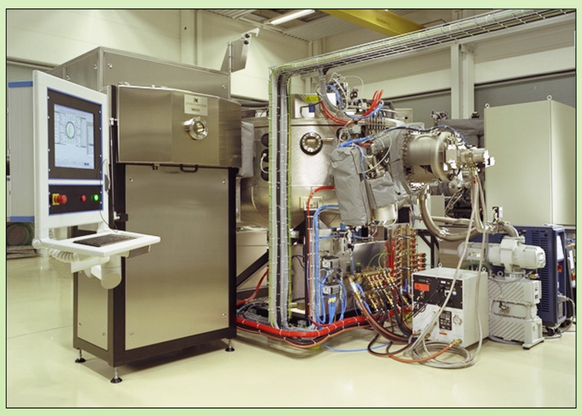


Fig. 4: New EUV Sputtering SYstem NESSY

NESSY specifications

Technology:	dc magnetron sputtering
Conception:	deposition of laterally graded multilayers on curved substrates
Substrate size:	up to Ø 660 mm (load locking up to Ø 400 mm)
Thickness homogeneity:	± 0.1 % on 300 mm

4. Results

Lateral multilayer gradient:

The error bars in Figure 5 correspond to a relative multilayer period error of d = 25 pm and hence to the specified peak wavelength of (13.50 ± 0.05) nm.

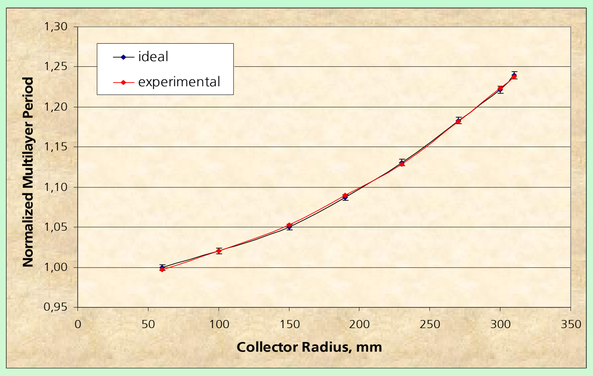


Fig. 5: Multilayer gradient, ideal and experimental data (normalized).

Reflectivity curves:

Figure 6 demonstrates the excellent wavelength matching for the 4 measured lines on the collector surface. Each line contains 25 single reflectivity curve measurements for radii between 60 mm and 315 mm and hence for angles of incidence from 7.7° to 35.9°.

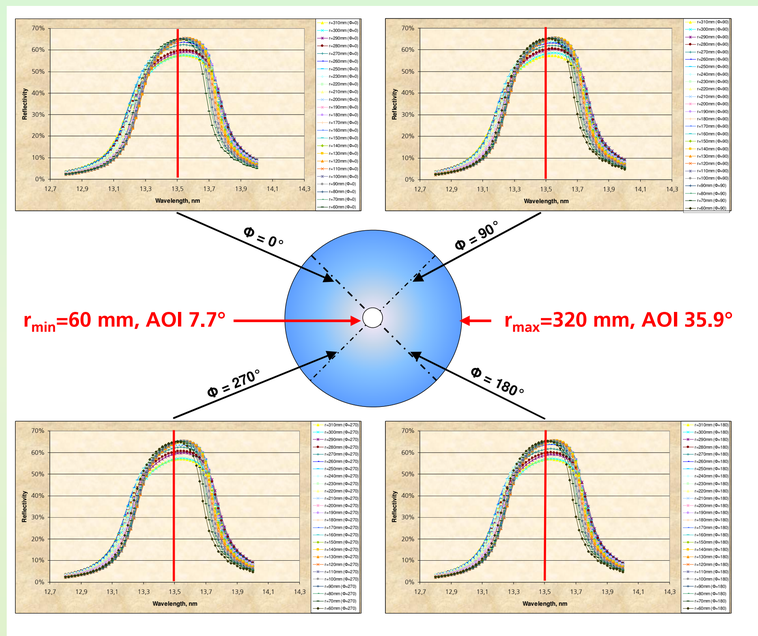


Fig. 6: 4 measured lines with 25 reflectivity curves each for radii 60 mm < r < 315 mm.

Maximum reflectivity:

Measured along 4 lines of the collector mirror for s-polarized light (Fig. 7):

R ~ 65% @ r < 240 mm

R ~ 59% @ r = 250 … 320 mm

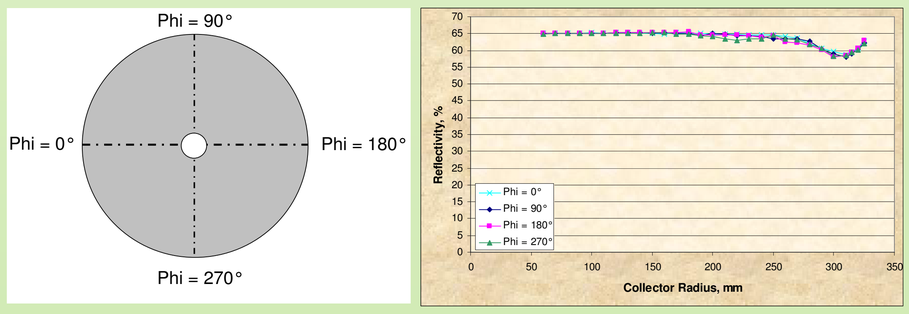


Fig. 7: Top view of mirror surface with 4 measured lines (left); maximum reflectance for radii 50 mm < r < 325 mm on 4 different lines on the collector surface (right).

5. Conclusion

The paper presents the successful coating of the world's largest ellipsoidal EUV collector mirror with a diameter of 660 mm. A maximum reflectivity of the laterally graded Mo/Si multilayer of more than 65 % was achieved for radii smaller than 230 mm. For radii between 240 mm and 325 mm the reflectivity decreases to a minimum of 59 %. The wavelength remains constant at (13.50 ± 0.50) nm over the entire collector surface which is well within the specifications for HVM.

Acknowledgements

The authors gratefully acknowledge the financial support for this work from Cymer Inc. The authors would like to thank Wieland Stöckl, Michael Scheler and Thomas Müller for technical support. We thank Frank Scholze, Christian Laubis and team (PTB Berlin) for EUV reflectivity measurements.

*marco.perske@iof.fraunhofer.de

Fraunhofer IOF

CYMER®